SYNOPSIS

DISTRIBUTION CHANNEL COORDINATION IN GREEN SUPPLY CHAIN MANAGEMENT

FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D.) IN MANAGEMENT

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Section I: Introduction

In the light of the current economic crisis, business has become very complex. On one hand, the organizations have to meet the exceeding competitive consumer's demands, and, on the other hand, they must now add the new perspective of environment friendly business practices as a social demand of civil society and government. The major challenge is to make the right product available to the consumer at the right place, on the right time and at the right prices in an eco-friendly manner with maximizing shareholders value. This underscores the importance of green supply chain management in the organizations. The environmental performance of product and processes often provide competitive advantage to the organizations. Therefore, it is critically important for the business to create distribution networks which are able to deliver the goods and services as per the consumer's need, keeping in mind the environmental concerns and profitability.

A. What is a Supply Chain?

The definition of Supply Chain Management as provided by the Global Supply Chain Forum is as follows:

> Supply Chain Management is the integration of key business processes from end user through original supplier that provides products, services and information that add value for customers and other stakeholders.

Until recently, the terms Supply Chain Management (SCM) and Logistics Management were used interchangeably. However, in October 1998, the Council of Logistics Management (CLM) announced a modified definition for Logistics Management as given below:

"Logistics is the part of the Supply Chain process that plans, implements and controls the efficient flow and storage of goods, services, and related information from the point of origin to point of consumption in order to meet customer requirements."

Clearly, from the above definition, Logistics Management emerges as only a part of SCM. For sake of completeness, we detail below some alternative definitions for SCM as given by various researchers in the literature.

Jones and Riley (1985):

An integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users.

Ellram (1991):

A network of firms interacting to deliver products or service to the end customer, linking flows from raw material supply to final delivery.

Christopher (1992):

Network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.

Lee and Billington (1992):

Networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers.

Berry, Towill and Wadsley (1994):

Supply chain management aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM (original equipment manufacturer) so as to release management resources for developing meaningful, long term relationship.

Saunders (1995):

External chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to the ultimate end customers.

Kopczak (1997):

The set of entities, including suppliers, logistics services providers, manufacturers, distributors and resellers, through which materials, products and information flow.

Tan, Kannan and Handfield (1998):

Supply chain management encompasses materials / supply management from the supply of basic raw materials to final product (and possible recycling and re-use). Supply chain management focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency.

Min and Zhou (2002):

A supply chain is referred to as an integrated system which synchronizes a series of inter-related business processes in order to (i) acquire raw materials and parts; (ii) transform these raw

materials and products into finished products; (iii) add value to these products; (iv) distribute and promote these products to either retailers or customers; (v) facilitate information exchange among the various business entities (e.g., suppliers, manufacturers, distributors, third-party logistics providers, and retailers). A supply chain is characterized by a forward flow of goods and a backward flow of information.

From the above definitions, it can be interpreted that the objective of SCM is to minimize system wide costs and maximize customer service levels. Alternatively, the objective of SCM can be interpreted as the maximization of the overall value generated for a customer. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in fulfilling the customer's request (Chopra and Meindl, 2001). A conventional supply chain focuses on the conversion of raw material to the finished product followed by its sale to a customer through the following sequential transformation stages: raw material supply, manufacturing, distribution, warehousing, and retailing.

The central focus of any supply chain initiative is, therefore, the efficient management of the flow of both tangible goods and information with the intention of enhancing profits, operational efficiencies and customer responsiveness. An aggressive pursuance of the above objectives could well manifest in the following benefits: throughput improvements; cycle time reduction; inventory cost reductions; optimized transportation; increased order fill rates; and increased customer service levels.

B. Major issues in Supply Chain Management

With increasing competition and uncertainties of environment the business is becoming more and more complex these days. Traditionally, the scope of supply chain management was limited to the production function. However, now it involves all the parties which directly or indirectly fulfil a customer's request. The "mantra" of marketing success, that is, having the right product in the right place at the right time, suggests why SCM has increasingly gained influence in areas which were originally the domain of marketing and marketing channel management. At the same time, however, it also demonstrates the possible synergies between the two disciplines. Supply chain management must address the following issues:

- **Distribution Network Configuration:** This includes decisions on number, location and network missions of suppliers, production facilities, distribution centres, warehouses, cross-docks and customers.

- **Distribution Strategy:** This decision includes questions of operating control (centralized, decentralized or shared); delivery scheme, direct shipment, pool point shipping, cross docking, DSD (direct store delivery), closed loop shipping; mode of transportation, e.g., motor carrier, including truckload, LTL, parcel; railroad; intermodal transport, including TOFC (trailer on flatcar) and COFC (container on flatcar); ocean freight; airfreight; replenishment strategy (e.g., pull, push or hybrid); and transportation control (e.g., owner-operated, private carrier, common carrier, contract carrier, or 3PL).

- **Trade-offs in Logistical Activities:** The above activities must be well coordinated in order to achieve the lowest total logistics cost. Trade-offs may increase the total cost if only one of the activities is optimized. It is imperative to take a systems approach when planning logistical activities.

- **Information:** This factor implies integration of processes through the supply chain to share valuable information, including demand signals, forecasts, inventory, transportation, potential collaboration, etc.

- **Inventory Management:** This includes decisions on quantity and location of inventory, including raw materials, work-in-process (WIP) and finished goods.

- **Cash-Flow:** This factor includes arranging the payment terms and methodologies for exchanging funds across entities within the supply chain.

This research would focus on the distribution aspects of supply chain management. Distribution function has traditionally been considered as part of marketing management. However, lately, with the advent of supply chain management, similar issues have begun to be addressed in operations management area also. Therefore, this research will address emerging issues in the inter-disciplinary area of marketing and operations management.

C. Distribution Channel – A Marketing Perspective

Distribution channel or marketing channel is defined as a set of independent organizations involved in the process of making a product or service available for use or consumption by the consumer or the end user (Kotler 1999). A company's channel decisions directly affect its marketing decision. Its pricing decision directly depends upon the efficiency of its distribution channel.

From the economic system's point of view, the role of marketing intermediaries is to transform the assortment of products made by producers into the assortment wanted by consumers. The intermediaries buy large quantities from many producers and break them in to

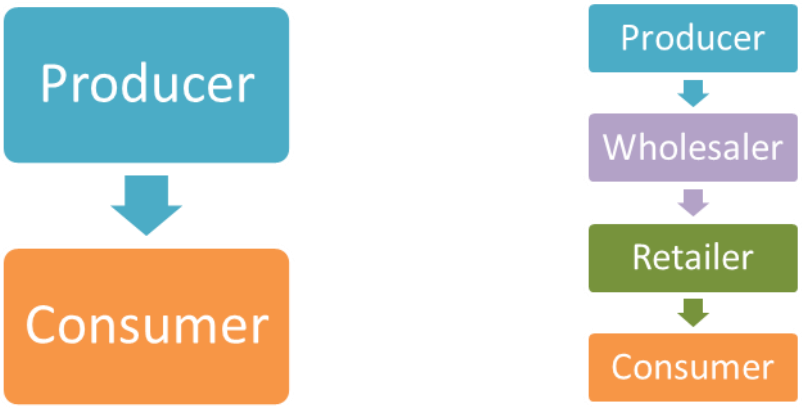
smaller quantities and broad assortments wanted by consumers. Thus, they play the important role in matching demand and supply. Through their contacts, experience, specialization and scale of operation, channel partners usually offer another firm more than it can achieve on its own. In making products and services available to consumers, channel members add value by bridging the time, place and possession gaps that separate goods and services from those who would use them.

Companies can design their distribution channels to make products and services available to consumers in different ways. Each layer of marketing intermediaries that perform some work in the bringing the product and its ownership closer to the final buyer is a channel level. Broadly the channels are divided into the following two extreme categories:

(i) Direct marketing channel: It is the channel which has no intermediary and the goods and services are directly transferred from manufacturer to the end consumer.

(ii) Indirect marketing channel: It is the channel which contains one or more than one intermediary levels.

The above two possible channel combinations are shown in Figure 1.1.



Direct Marketing Channel (I) **Indirect Marketing Channel (II)**

Figure1.1: Classification of Distribution Channel

D. Environmental Concerns in Supply Chain Management and Distribution Channel

From a distribution (a marketing view) or a supply chain (an operations view) perspective, the phenomenon of green management has opened up several interesting and challenging problems for both the practitioners and researchers. In response to these challenges, a relatively new stream of research has emerged, which is labelled as green supply chain management (Srivastava 2007). A number of research issues have been addressed in this area ranging from green design (Zhang et al.

1997), reverse logistics (Flieschmann et al. 1997), product recovery (Gungor and Gupta 1999), logistics design (Jayaraman et al. 2003), and so on.

As an example, consider the following concerns of Unilever managers in their direct competition with P&G on Wal-Mart's shelves:

"On my grocer's shelf are a bulky, 100-fluid-ounce, orange plastic jug of Procter & Gamble's bestselling Tide and a slim 32-ounce aqua plastic bottle of Unilever's "small and mighty" All. Both contain enough detergent for 32 loads of wash, but the smaller package, made possible by condensing All, saves energy, shipping costs, and shelf space - a big win all around, right? Not quite. Bigger packages command more shelf space, provide more surface area for advertising, and suggest to consumers that they're getting more for their money. Unilever executives voiced all those worries when they went to see Scott [the Wal Mart CEO]." (Gunther 2006).

The above quote aptly represents the dilemma faced by a manufacturer, who invests heavily in making his product more environment-friendly, only to realize later that it also has to balance this against the realities of market place (i.e., consumer behavior). Recently, such dilemmas have begun to be addressed in the broad field of green supply chain management (Swami and Shah 2011). This is a rapidly emerging field since environmental consciousness has become intertwined with everyday life and sound business practices (Intergovernmental Panel on Climate Change 2007).

A 2003 report by U.S.-based non-profit government consulting institute, LMI Research Institute, mentions that, particularly in the manufacturing sector, there has been increased scrutiny of the items being purchased for use in various processes, the effects of processes, and the packaging and delivery of the products. The effort to reduce the impact of these activities on the environment has been labelled as green supply chain management. This report states that "Firms have generally taken two approaches to greening their supply chains. The first looks externally to its various suppliers. Suppliers are asked to provide evidence of their operations meeting relevant environmental requirements and, in some cases (Toyota and Ford for example), evidence of ISO14001 certification. The second approach is an internal examination of how a firm designs, produces, and ships its products." (LMI Report 2003, p. 2.8)

Examples have also begun to emerge from practice regarding the economic benefits of the adoption of the green practices. Commonwealth Edison reported financial benefits of $50 million annually from managing material and equipment with a life-cycle management approach. Pepsi saved $44 million by switching from corrugated to reusable plastic shipping containers. Similar savings have been reported by Texas Instruments and Dow Corning (Wilkerson 2005). Rao and Holt

(2005) specifically mention that greening different phases of a supply chain may eventually result in an integrated supply chain, which in turn would ensure better economic performance and competitiveness.

The research area of green supply chain management has opened up several interesting and challenging problems for both the practitioners and researchers. However, very few studies have addressed the issue of coordinating the green supply chain.

E. Channel Coordination Issues in Marketing

One of the important research areas in supply chain management is related to the conflict and coordination issues that can arise between various players in the chain. These issues or conflicts can be both horizontal and vertical in nature. The horizontal conflicts are between the players at the same level of the supply chain, while the vertical conflicts are between the players at the upstream (say, a manufacturer) and downstream (say, a retailer) levels of the chain. In this research, we will focus on the vertical conflicts in a supply chain. Starting from the seminal papers on channel coordination in marketing literature (McGuire and Staelin 1983; Jeuland and Shugan 1983), considerable research has been done in this area on the issues ranging from strategic decentralization (Moorthy 1988), manufacturers' competition (Choi 1991), quantity discounts and two-part tariffs (Ingene and Parry 1995), vertical strategic interaction (Lee and Staelin 1997), benefits of channel discord (Arya and Mittendorf 2006), demand perishability (Raut et al. 2007), and so on. With the general assumption of a deterministic demand function, the above stream of research has focused on a variety of issues, as listed above.

Another stream of research in the supply chain coordination has taken the route of modelling the role of stochastic demand in supply chain coordination. This stream of research is grounded in the classical newsvendor problem. Various models have extended the newsvendor model by allowing the retailer to choose his retail price in addition to his stocking quantity, retailer to exert costly effort to increase demand, tempering of downstream competition, stochastic demand with multiple replenishment opportunities, infinite horizon model, making the supplier hold inventory, transfer prices, information asymmetry, and so on. An excellent review of this stream of research appears in Cachon (2003).

Although considerable amount of research has been done in the above areas, very few studies have addressed the issue of coordinating the green supply chain. Yet, a characteristically different set of conflicts between channel partners, and the requirement for coordination thereof, may arise in situations involving green supply chains. Examples of these conflicts include different

incentives for the channel partners to invest in green practices, the effect of investments in greening efforts on price determination, competition among green suppliers, competition among green retailers, reverse channel design, and so on. Lately, however, some research has begun to emerge in the research area of the coordination of green supply chain (Swami and Shah 2011; Goldbach, Seuring and Back 2003; Vachon and Klassen 2006; Savaskan and van Wassenhove2006; Mitra and Webster 2008).

Section II: Conceptual Framework for Green Supply Chain Management

In this section, we begin with a broad-level conceptual framework aimed at understanding analytically the overall concept of green supply chain management (referred as GrSCM hereafter). Based on this framework, we explain the construct of GrSCM in terms of its antecedents and consequences. The antecedents or consequents of GrSCM have been reported extensively in prior literature. These are compiled into a concise framework provided by Srivastava (2007). Based on Srivastava's (2007) framework, the antecedents to GrSCM can be classified into the following categories: (i) Green Design, (ii) Green Manufacturing, (iii) Green remanufacturing, (iv) Reverse Logistics, and (v) Waste management.

On the consequences side, there are some studies that have investigated the link between greening efforts by a firm and its economic performance. For example, Rao and Holt (2005) show that greening the different phases of a supply chain leads to an integrated supply chain which ultimately leads to better competitiveness and economic performance. However, virtually none of the studies has attempted to examine the constituents or source of this superior economic performance. In other words, it is not clear as to where the superior economic performance is coming from? Towards this end, we invoke the simple equation of profitability as a measure of economic performance:

Profit = (Price per unit – Cost per unit) * Quantity demanded

Based on the different elements of this equation that could be affected by the firm's greening effort, represented by the symbol *(*τ), we can write the above equation as:

$$\pi(\tau) = [p(\tau) - c(\tau)] * Q(\tau) \quad (1)$$

π, *p, c*, and *Q* denote total profit, price per unit, cost per unit, and quantity demanded, respectively. (τ) can be interpreted as an index of a firm's greening efforts.

This relationship gives rise to three consequences of greening efforts, which could lead to increased profits of a firm. The first consequence could be *price premium* that a firm could charge its consumers because of its greening efforts. This could be possible due to the positive image that a company builds as an environmentally-conscious concern. The second consequence could be *reduction in cost* per unit, which can be facilitated by effective green manufacturing and re-manufacturing efforts (e.g., reduction, recycling, refurbishing, reuse, etc.). Finally, the third consequence could be *demand expansion,* which refers to the increase in quantity demanded of a

firm's products as a result of its greening efforts. To differentiate between the first and third consequences, while the price premium effect is meant to reflect the consumers' tendency to be willing to pay more for its greening efforts, the demand expansion effect means that, given two manufacturers selling nearly identical product, a customer would be more will be willing to purchase the one that is more environment friendly. It is clear that the latter effect may arise independently of the relative prices of the products. The above discussion is summarized in Figure2.1.

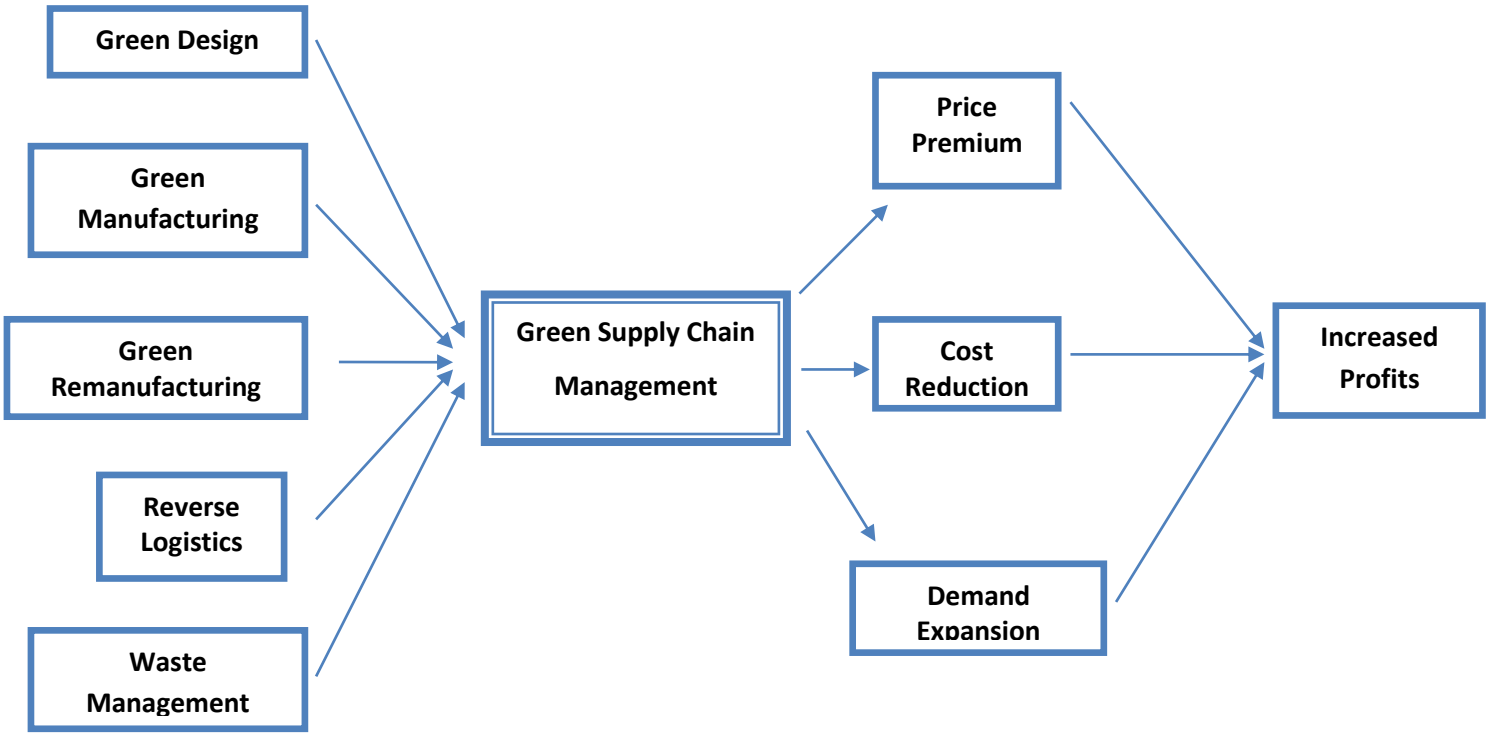


Figure 2.1: Antecedents and Consequences of Green Supply Chain Management

Section III: Literature Review

In this section, we provide the relevant literature review in the area of this thesis. A graphical view of the literature review is provided in the figure below:

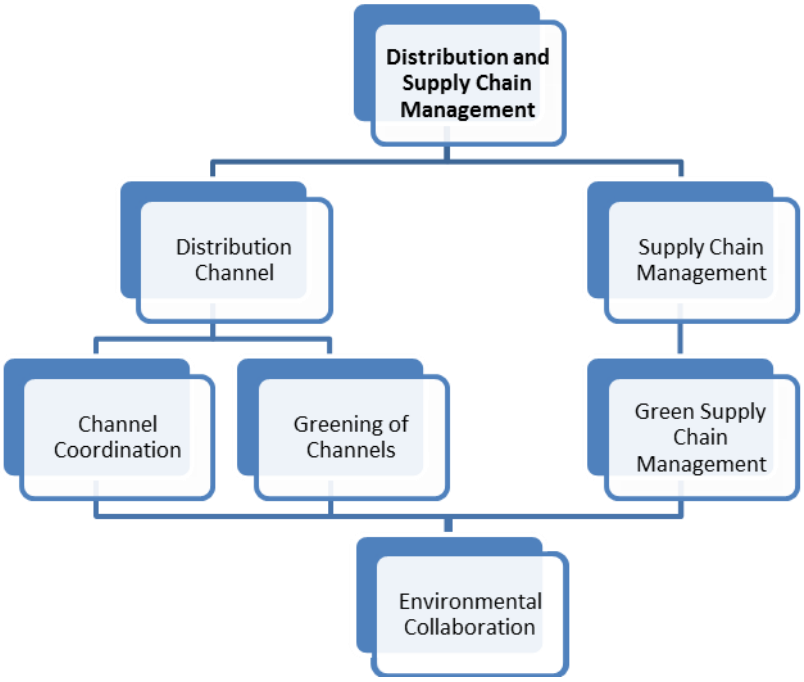


Figure 3.1: Literature Review at a Glance

A. Distribution Channel

Ever since the academic debate began on the theoretical foundation of marketing, the "creation of value through exchange processes" (Sheth, et al. 1988, p. 201) has been widely accepted as the *raison d'être* of marketing. Today, the value orientation is more prevalent than ever before and marketing is related to customer value-creating processes (Piercy 1998, Flint 2004). In markets with shortening lifecycles and a shifting balance of power from the supplier to the customer, the informed customer dictates what they want, where and why. Customers buy products or services to solve their problems and they value their purchases according to their perceived and benefit. Creation of such value can be done through better management of distribution channel (Kotler 1999). Most recently, the proactive role of the various channel partners in the value creation process has emphasised (Vargo and Lusch 2004).Two theoretical foundations, the economic value theory of the firm (Slater 1997) and the customer value theory (Woodruff 1997), emphasise the importance of distribution channel in terms of creating economic value for firm as well as customer (Zablah et al. 2004).

Within the SCM literature, most of the contributions which aim to define distribution channel in reference to the importance of integrating marketing into the SCM concept. For example, Cooper et al. (1997) and Lambert and Cooper (2000) define SCM as the integration and management of key business processes across the supply chain. They outline three marketing-related business processes: (1) Customer Relationship Management, (2) Customer Service Management and (3) Distribution Channel Management. The distribution channel management process, in particular, must balance the customer's requirements with the firm's capabilities and use key customer data to reduce uncertainty and provide efficient flow throughout the supply chain. Mentzer et al. (2001) also build their model of SCM on inter functional coordination of key channel partners and marketing related functions.

Similarly, Bechtel and Jayaram (1997) suggest a research agenda for SCM and emphasise the need for the supply chain to begin with the customer. They propose that a better term would be seamless demand pipeline, where the end user, and not the supply function, drives the supply chain. Fisher (1997) links the integration of marketing into SCM to the concept of the supply chain's market mediation role. Within this role, the supply chain needs to ensure that the variety of products reaching the marketplace matches what consumers want to buy. Min and Mentzer (2000) emphasise the important role that marketing orientation and relationship marketing play in the implementation of SCM. Finally, the efficient consumer response (ECR) approach is another area which emerged within the logistics community and clearly addresses the interface between marketing and SCM (e.g., Alvarado and Kotzab 2001).

B. Channel Coordination

Jeuland and Shugan (1983) define channel coordination as the setting of all manufacturer and retailer-related decisions at the levels that would maximize total channel profits. In this context, the seminal work by McGuire and Staelin (1983) studied the impact of product substitutability on Nash equilibrium distribution structures where each manufacturer distributes its goods through an exclusive retailer. Jeuland and Shugan (1983) focused on channel coordination in the context of a single manufacturer and a single retailer structure. They find that coordination between a manufacturer and a retailer using a quantity discount schedule could lead to higher profit for channel members. Moorthy (1988) examines the effect of strategic interaction on a manufacturer's channel structure decisions.

Choi (1991) considers a channel structure consisting of two manufacturers and a single common retailer. His model addresses three types of games: the Manufacturer– Stackelberg game,

the Retailer–Stackelberg game and Vertical–Nash equilibrium. Ingene and Parry (1995) studied channel coordination by focusing on a single manufacturer using two competing retailers. They use a Stackelberg game, in which the manufacturer could apply either a two-part tariff scheme or a schedule for quantity discounts. They find that while quantity discount schedule facilitates channel coordination, the two-part tariff does not. Lee and Staelin (1997) provide a more generalized model allowing two manufacturers to interact with two retailers. Iyer (1998) analyses how manufacturers should coordinate distribution channels when retailers compete in price as well as important non-price factors such as the provision of product information, free repair, faster check-out, or after-sales service.

Jorgensen et al. (2001) examine dynamic advertising and promotion strategies in a marketing channel where the retailer promotes the manufacturer product and the manufacturer spends on advertising to build a stock of goodwill. The results show that the cooperative advertising program is a coordinating mechanism in the marketing channel. More recently, Arya and Mittendorf (2006) provided a counter-intuitive result that sometimes a separated, as opposed to vertically integrated, channel that embodies a degree of discord can be helpful from a long-term viewpoint. From the applications perspective, Raut et al. (2008) provide an innovative application of channel coordination in the motion picture industry characterized by a dynamic market environment, limited shelf space, product category management, and complex contractual practices They find that simpler contracts (e.g., two-part tariff, or 50/50) could be better than more complicated contracts.

C. Greening of Channels for Coordinating Green Supply Chain

Some research has begun to emerge in the area of the coordination of green supply chain. Vachon and Klassen (2008) mention that as corporations attempt to move toward environmental sustainability, management must extend their efforts to improve environmental practices across their supply chain. Using a survey of North American manufacturers, their paper examines the impact of environmental collaborative activities on manufacturing performance. Environmental collaboration was defined specifically to focus on inter-organizational interactions between supply chain members, including such aspects as joint environmental goal setting, shared environmental planning, and working together to reduce pollution or other environmental impacts. These practices can be directed either upstream toward suppliers or downstream toward customers.

Walton et al. (1998) consider the case of how to integrate suppliers into the environmental management processes of green supply chain. Using survey-based approach, they find that it is

beneficial for purchasing companies to influence the suppliers' environment management practices. Similar results have been reported by Rao (2002) in South-East Asian context.

Kogg (2003) reports the case study of a greening a cotton-textile supply chain, which specifically considers the case when the suppliers have greater channel power. Goldbach, Seuring and Back (2003) provide a case study on the introduction of a sustainable cotton supply chain at a German mail-order business OTTO. The major difficulty arising in the chain was how to coordinate the activities of a complex network of different players involved in the chain. In the practical setting considered, the coordination required a set of hybrid approaches at different levels, ranging from market-like structures to hierarchical ones based on command-and-control mechanisms.

Vachon and Klassen (2006) consider the impact of upstream and downstream integration on extending green practices across the supply chain. It was found that technological integration with primary suppliers and major customers was positively linked to environmental monitoring and collaboration. For logistical integration, a linkage was found only with environmental monitoring of suppliers.

Simpson et al. (2007) explore the moderating impact of relationship conditions existing between a customer and its suppliers on the uptake and effectiveness of the customer's green supply chain performance requirements. In a setting of automotive supply chain, they find that suppliers were more responsive to their customers' environmental performance requirements where increasing levels of relationship-specific investment occurred. Similar issues were explored by Simpson and Power (2005).

Mitra and Webster (2008) analyze a two-period model of a manufacturer who makes and sells a new product and a remanufacturer who competes with the manufacturer in the second period. They examine the effects of government subsidies as a means to promote remanufacturing activity. They find that the introduction of subsidies increases remanufacturing activity, and that the manufacturer's profits generally decrease while the remanufacturer's profits increase when 100% of the subsidy goes to the remanufacturer.

D. Green Supply Chain Management

Zhang et al. (1997) provide a comprehensive review of green design through a term introduced by them as "Environmentally Conscious Design and Manufacturing (ECD&M)". Around the same time, Flieschmann et al. (1997) surveyed the then rapidly emerging field of reverse logistics. They subdivided the field into three main areas, namely distribution planning, inventory control, and

production planning. For each of these, the implications of the reuse efforts, mathematical models proposed, and areas in need of further research were discussed. Beamon (1999) discusses the development of environmental management (EM) strategies for the supply chain. Her research investigates the environmental factors leading to the development of an extended environmental supply chain, describes the elemental differences between the extended supply chain and the traditional supply chain, and develops a general procedure towards achieving and maintaining the green supply chain. Sarkis (2003) posits a strategic decision framework for green supply chain management. Jayaraman et al. (2003) discuss the models and solution procedures regarding the design of reverse distribution networks.

Linton et al. (2007) provide an introduction to sustainable supply chains. They give consideration to the convergence of supply chains and sustainability. Srivastava (2007) provides a comprehensive literature review of a broad frame of reference for green supply-chain management (GrSCM). A succinct classification is aimed at helping academicians, researchers and practitioners in understanding integrated GrSCM from a wider perspective. Srivastava (2008) also provides an integrated holistic conceptual framework that combines descriptive modelling with optimization techniques for network design in reverse logistics.

E. Environmental Collaboration

Environmental collaboration can be defined as the direct involvement of an organization with its suppliers and customers in planning jointly for environmental management and environmental solutions. The focus is on collaboration between a focal plant and its suppliers and/or its customers. Within a rich collaborative context, suppliers and customers plan together the reduction of environmental impact from production processes and products. Environmental collaboration includes the exchange of technical information and requires a mutual willingness to learn about each other's operations in order to plan and set goals for environmental improvement. It also implies cooperation to reduce the environmental impact associated with material flows in the supply chain (Bowen et al., 2001; Carter and Carter, 1998).

Finally, environmental collaboration comprises a good understanding of each other's responsibilities and capabilities in regard to environmental management. This definition contrasts with similar concepts put forward in the literature. First, environmental collaboration activities are not concentrated only on products (Bowen et al., 2001), but also include production processes. Second, unidirectional and control-oriented activities such as site audits, questionnaires, and other buyers' requirements that are often blended in the conceptualization of green supply chain (Zhu and

Sarkis, 2004) are not included in environmental collaboration; instead, the focus is on environmental collaboration, not environmental monitoring (Vachon and Klassen, 2006).

As such, environmental collaboration focuses less on the immediate outcome of the supplier- or customer-environmental efforts (e.g., compliance to existing regulations), and more on the means by which more environmentally sound operations or products might be achieved. Because each focal plant acts as a buying organization to its suppliers and as a supplier to its customers, such collaboration can take place simultaneously upstream with the suppliers, as well as downstream with the customers (Vachon and Klassen, 2006).

Section IV: Need of the Study

World Summit on Sustainable Development (2002) in Johannesburg proposed a triplet term *people - planet – prosperity* to reflect the fact that sustainable development required balancing of social, economic and environmental issues (White and Lee 2007). Indeed, in the recent past, the concept of environmental consciousness has become intimately intertwined with both everyday life and sound business practices (Intergovernmental Panel on Climate Change 2007).Environmental responsibility has moved from a trend to a business imperative. Sustainability is about reducing carbon footprint, complemented by minimizing waste and conserving water through innovation, communication and best practices.

Traditionally, from the business perspective, the issue of environmental consciousness, or "green management", had raised a conundrum in which economic concerns were perceived at odds with the ecological concerns. Lately, however, the literature has begun to recognize the needlessness of this "stalemate" between being green and competitive (Porter and van der Linde 1995; Rao and Holt 2005). GrSCM integrates environmental thinking into supply chain management (SCM). Firms engaging in green supply chain management have experienced many benefits, both environmentally and financially. Following are some of the examples of the companies regarding the economic benefits of the adoption of the green practices. For example, Commonwealth Edison reported financial benefits of $50 million annually from managing material and equipment with a life-cycle management approach. Pepsi-Cola saved $44 million by switching from corrugated to reusable plastic shipping containers for one litre and 20-ounce bottles. Similar savings have been reported by Texas Instruments and Dow Corning (Wilkerson 2005). Nestlé employs an on-going, company-wide sustainability program that has generated significant environmental and financial benefits. Heineken committed to reduce fuel and electricity use through its "Aware of Energy" program. In addition, a Mckinsey report in April 2012 has introduced a new concept of supply circles. Shifting from supply chains to supply circles manufacturers can evolve from linear to circular operating models—repairing, recycling, and reinventing products, components, and materials—that can reduce costs and improve productivity in a more environment friendly manner.

It is clear that any major greening project would require efforts on the part of the entire supply chain, as discovered by Wal-Mart (Plambeck 2007). However, very few studies have addressed the issue of coordinating the green supply chain. We focus on the vertical conflicts in a green supply chain, that is, the conflicts between the players at the upstream (say, a manufacturer) and downstream (say, a retailer) levels of the chain. Some pertinent questions in this regard are: Who should be investing in the greening effort? Should it be retailer, or manufacturer, or both?

Should they work on greening initiative independently? Should different entities in the supply chain coordinate the greening effort? If yes, then how? Should the greening efforts be outsourced? And so on.

As mentioned earlier, although a lot of work is beginning to emerge in the important area of green supply chain management, few analytical modelling based studies have been proposed in the literature. It is clear that such studies would be highly desirable from knowledge development perspective, and to answer important questions such as: greening efforts by upstream and downstream players, impact on prices due to greening effort, channel coordination mechanism and so on. A beginning in this context has been made by state-of- the- art research work by Swami and Shah (2012). The proposed research work falls in this stream of research and aims to extend it further with newer dimensions and complexities.

Section V: Objectives

This research work is focussed in the area of green supply chain management with a view to enable business organizations to maximise returns in an environment friendly manner through innovative distribution channel strategies. The attempt is to propose such contractual agreements and strategies which will make the supply chains as profitable as the traditional once keeping the green element intact. Specifically the objectives of the proposed thesis are as follows:

Objective 1: To lay down the conceptual foundation of the general area of Green Supply Chain Management.

Objective 2: To review and analyse the major successful case studies in the broad area of Green Supply Chain Management.

Objective 3: To identify the sources and reasons of distribution channel conflicts in both supply chain management and Green Supply Chain management.

Objective 4: To mathematically model and analyse the situations of channel conflict in green supply chain management using different market situations (1 Manufacturer-1 Retailer), (*n* Manufacturers – 1 Retailer), (1 Manufacturer – *n* Retailers), (*n* Manufacturer – *n* Retailers).

Objective 5: To recommend optimal strategies for the supply chain players through optimisation techniques.

Objective 6: To perform numerical analysis and develop a decision support system for different scenarios listed in objectives.

Section VI: Research Methodology

The research design will be exploratory, descriptive and analytical in nature. Use will be made of secondary data that exist in the literature. Further, the following concepts or tools will be used in the thesis:

A. Mathematical Model

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modelling. Eykhoff (1974) defined a mathematical model as a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form. A model may help to explain a system and to study the effects of different components, and to make predictions about behaviour.

Mathematical models can take many forms, such as dynamical systems, statistical models, differential equations, or game theoretic models. These and other types of models can overlap, with a given model involving a variety of abstract structures. Indeed, the quality of a scientific field depends on how well the mathematical models developed on the theoretical side agree with results of repeatable experiments. In this research, we will make use of deterministic modelling. A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables. Deterministic models have the advantage of being easy to conceptualise, and drawing implementable interpretations and rich insights.

B. Optimization

Optimization is an act, process, or methodology of making something (as a design, system, or decision) as perfect, functional, or effective as possible. It usually involves the mathematical procedures (e.g., finding the maximum of a function) In other words, it refers to the selection of a best element from some set of available alternatives. An optimization approach consists of maximizing or minimizing a function by systematically choosing input values from within an allowed set and computing the value of the function. More generally, optimization includes finding "best available" values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domains. The proposed research would be dealing with the following techniques:

Nonlinear Programming

Nonlinear programming (NLP) is the process of solving a system of equalities and inequalities, collectively termed constraints, over a set of unknown real variables, along with an objective function to be maximized or minimized, where some of the constraints or the objective function are nonlinear.

First order and Second Order Optimality Conditions

For any optimization problem, the first order condition is that the first derivative of the given function with respect to its variable is equated to zero. That means if *y* is a function for a given variable *x, (y= f(x))* then $\frac{dy}{dx} = 0$, this condition is necessary to determine the extremum of the function. However, it is not sufficient to determine if the function is at the maximum or minimum. The test for a maximum or minimum using the second order derivative of the same function is called the second order condition (S.O.C). In the above example, taking the second derivative of the function, if $\frac{d^2y}{dx^2} > 0$ then it is a minima, and if $\frac{d^2y}{dx^2} < 0$, then it is a maxima at point of extremum, for a single variable function.

In a multivariable function, for first order condition, partial derivative is taken with respect to each variable of the function and all must be equated to zero individually, that is, $\frac{\partial y}{\partial x_i} = 0$. For a second order condition, we need to find the values of all the independent variables and then we test for maxima or minima at extremum point for the function.

C. Game Theory

Game theory is the study of strategic decision making. More formally, it is the study of mathematical models of conflict and cooperation between intelligent rational decision-makers. According to the Stanford Encyclopaedia, Game Theory is the study of the ways in which strategic interactions among economic agents produce outcomes with respect to the preferences (or utilities) of those agents, where the outcomes in question might have been intended by none of the agents. In our thesis, we will mainly use Stackelberg Equilibrium and Nash Equilibrium concepts pertaining to game theory.

The Stackelberg leadership model is a strategic game in economics in which the leader firm moves first, and then the follower firms move sequentially. It is named after the German economist Heinrich Freiherr von Stackelberg who published Market Structure and Equilibrium (Marktform und Gleichgewicht) in 1934, which described the model. In game theory terms, the players of this game are a leader and a follower, and they compete on quantity. The Stackelberg leader is sometimes

referred to as the Market Leader. There are some further constraints upon the sustaining of Stackelberg equilibrium. The leader must know *ex ante* that the follower observes his action. In the proposed research, we take an example of manufacturer and retailer. The manufacturer is a Stackelberg leader, and will first decide the wholesale price *w*. Then, the retailer decides the retail price *p* with an objective of optimising their profit, π_m and π_r. In a Stackelberg game structure, first, the manufacturer will decide the best response function for the retailer (π_r) by estimating the retail price *p* with respect to wholesale price *w*. This gives profit of retailer as a function of wholesale price [$\pi_r = f(w)$].The resulting response function the manufacturer decides on optimum wholesale price w^* and further the retail price p^* is decided with the help of first order conditions for π_m and π_r, respectively. With the help of these values (w^* and p^*) we get the optimum profit for manufacturer (π_m^*) and retailer (π_r^*) respectively.

In game theory**,** Nash equilibrium (named after John Forbes Nash) is a solution concept of a game involving two or more players, in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only his own strategy unilaterally. If each player has chosen a strategy and no player can benefit by changing his or her strategy, while the other players keep theirs unchanged, then the current set of strategy choices and the corresponding payoffs constitute Nash equilibrium. In Nash equilibrium situation, in the above example of manufacturer and retailer, both players decide their prices simultaneously. That means the manufacturer will decide his price *w* and will try to optimise the profit π_m and the retailer will decide his price *p* and will try to optimise his profit π_r. Using the optimality conditions, we get the values of w^* and p^* and with that we get optimum profit for manufacturer (π_m^*) and retailer (π_r^*), respectively.

D. Numerical Analysis

Numerical analysis involves the study of methods of computing numerical data. It includes the set of algorithms that use numerical approximation for the problems of mathematical analysis. The overall goal of the field of numerical analysis is the design and analysis of techniques to give approximate but accurate solutions to various problems. In proposed research, we will be examining the changes in parameter values, and its effect on optimal decisions, with reference to proposed models.

E. Case Studies

Case studies are analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods. The case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical frame within

which, the study is conducted and which the case illuminates and explicates. Case study is a research strategy, an empirical inquiry that investigates a phenomenon within its real-life context. It provides a systematic way of looking at events occurred in real life scenario in past and help in drawing meaningful support in the context of the research. In our proposed research, we will analyze the successful case studies in the area of green supply chain management. The list of proposed companies, to be analyzed for green initiatives in thesis is as follows:

S. No.	Company Name
1.	Wal-Mart
2.	DuPont
3.	Goodyear
4.	EV Logistics
5.	GE
6.	PepsiCo
7.	Hewlett-Packard
8.	Unilever

F. Depth Interview

It is an unstructured, direct, personal interview in which a single respondent is probed by a highly skilled interview to uncover underlying motivations, beliefs, attitudes, and feeling on a topic. Depth interviews are often conducted with industry experts. The interviewer attempts to follow a rough outline, the specific wordings of the questions and the order in which they are asked is influenced by the subject's replies. The three major depth interview techniques are laddering, hidden issue questioning and symbolic analysis. In laddering, the line of questioning proceeds from product characteristics to user characteristics. This technique allows the researcher to discover the different meanings assigned by experts to an object or issue. In hidden issue questioning, the focus is on deeply felt personal concerns of the experts. Symbolic analysis attempts to analyse the symbolic meaning of objects by comparing them with their opposites. In our proposed research, we will focus on senior management of various companies with an objective of assessing the opportunities and

challenges in the area of green supply chain management. The list of proposed target companies is as follows:

S. No.	Company Name
1.	SRF Ltd.
2.	DSCL Ltd.
3.	Cisco Systems
4.	TCS
5.	Texas Instruments
6.	Reliance
7.	HUL
8.	Wal-Mart

G. Tools

The major work in our research is based on modelling and computational analysis. Following tools will be used for providing the platform for modelling and analysis:

Wolfram Mathematica

Mathematica is computer software which is used for computation and mathematical modelling. It is widely used for solving symbolic mathematical expressions and complex equations. This is also used to provide graphic representations to the mathematical expressions and equations.

Matlab

MATLAB is a programming environment for algorithm development, data analysis, visualization, and numerical computation. It is widely used for customising the computational platform for a specific set of problems.

Section VII: Preliminary Statement of Mathematical Models to be Analysed in the Research and Conclusions

As mentioned earlier, Swami and Shah (2012) have proposed the model of a single manufacturer who sells its products to a single retailer. Both the manufacturer and retailer put in some effort for greening their operations. The manufacturer decides on the wholesale prices and its greening efforts, while the retailer decides on the retail price and its corresponding greening efforts. We wish to examine the effect of various parameters, such as, price sensitivity, effectiveness of greening efforts, and cost of greening, and other factor on the optimal pricing and efforts decisions by the channel partners. The demand of the product generated at the retail end is a function of the retail price and the greening efforts by both manufacturer and retailer. Thus, it may be in the interest of both the manufacturer and retailer to contribute jointly to this effect on profit generation. The structure of the supply chain in this context is as follows:

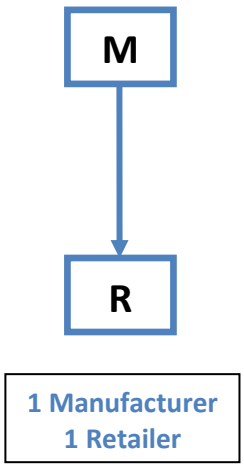


Figure 6.1: Single Player Structure of the Supply Chain

In the proposed research, we introduce competition at the retailer as well as the manufacturer level and will analyse its effect on the various parameter stated above. We will also give numerical examples to validate the proposed models. Following are the structures of supply chain in which the analysis would be done:

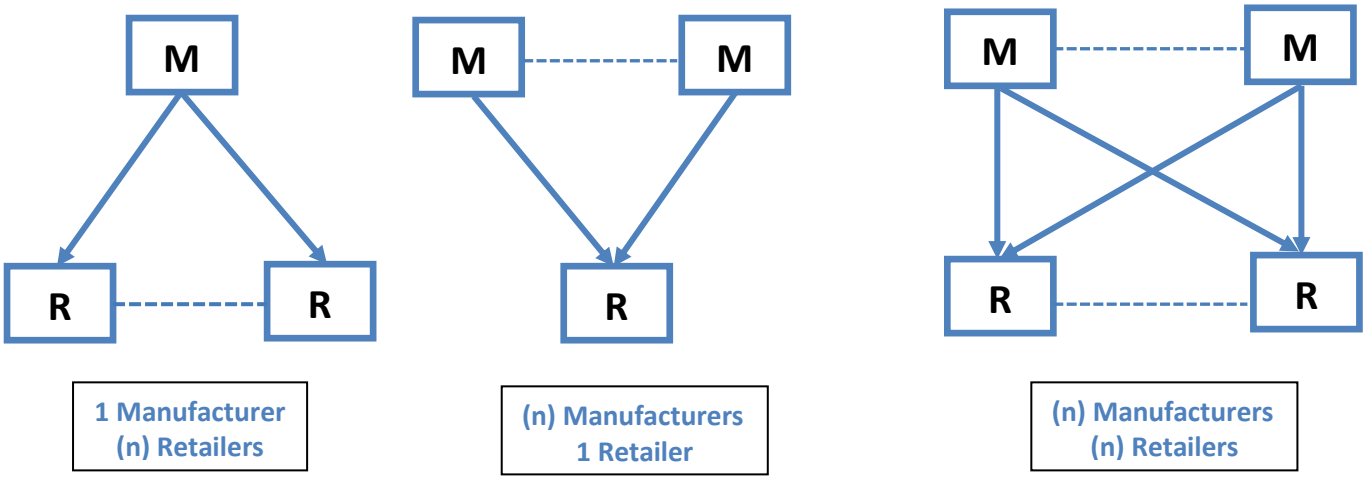


Figure 6.2: Multiplayer Structure of the supply Chain

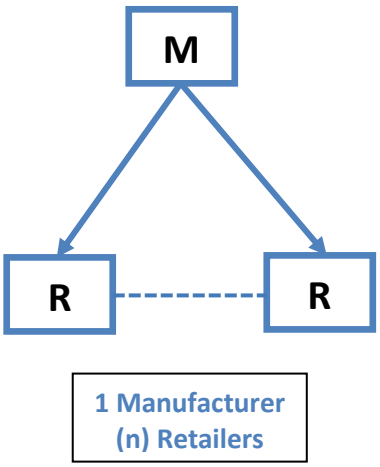


Figure 6.2 (a): Market Structure One: Dominant Manufacturer with Multiple Retailers

As shown in the Figure 6.2 (a) above, we first examine the case of one manufacturer dealing with multiple (n) retailers. This situation exemplifies the case in many markets in which a dominant manufacturer (say P&G) deals with several small retailers. Thus, in this case, we have competition at the retail level.

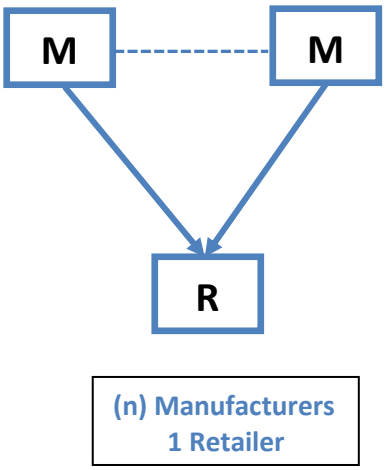


Figure 6.2 (b): Market Structure Two: Multiple Manufacturers with Dominant Retailer

In Figure 6.2 (b) above, a converse situation of the earlier model is considered. Thus, here multiple manufacturers deal with a common dominant retailer (say, Wal-Mart).

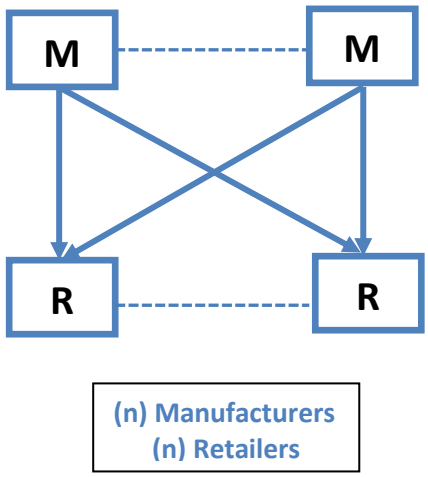


Figure 6.2 (c): Market Structure Three: Equally Powerful Manufacturers and Retailers

Finally Figure 6.2 (c) considers the market situation in which multiple manufacturers deal with equally strong multiple retailers. This situation is indicative of many markets found these days in modern retailing.

Thus Figures 6.2 (a), (b) and (c) are representative of several important market structures and real situations. A comparison of results found in the three scenarios will throw important and interesting insights into distribution channels in green supply chain management.

As an outcome of the proposed research, such contracts would be designed which will yield better economic value in the supply chains with better efficiency and optimum resource utilisation in an environment friendly manner. Optimal analytical expression would be provided for total channel profit, retail price, wholesale price, greening effort by manufacturer and retailer in integrated and decentralised channels.

Section VIII: Proposed Chapter Plan

The list of proposed chapters is as follows:

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Conceptual Framework

Chapter 4: Research Design

Chapter 5: Mathematical Models

Chapter 6: Analysis and Results

Chapter 7: Managerial Implications

Chapter 8: Conclusions and Direction for Future Research

Appendices

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